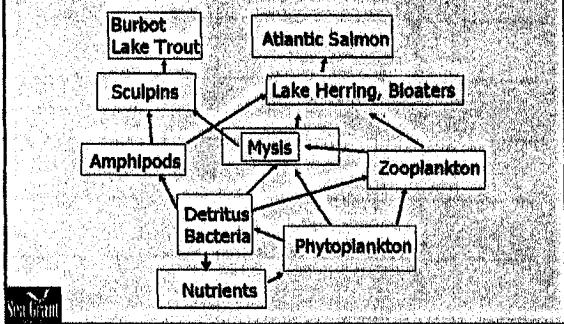
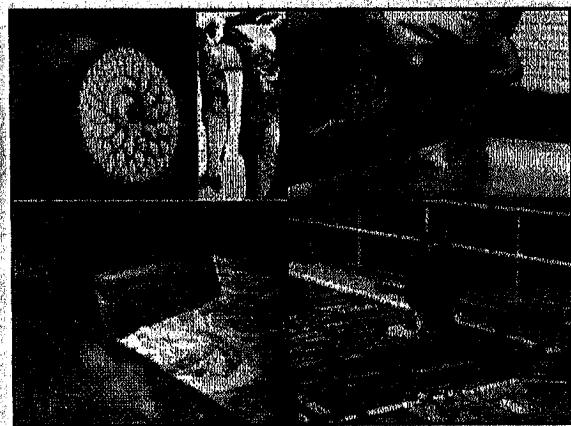
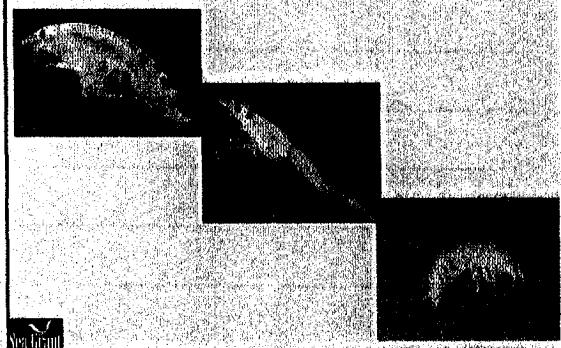


Lake Ontario Food Web: Pre-1850s

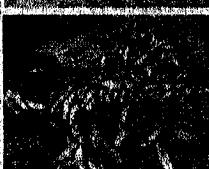
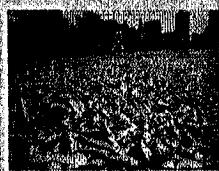


Important Native, Benthic Invertebrates



Enter the "Evil Alewife": a Paradox

It looks benign, but it has been a serious nuisance species and a benefit!?



Mass die-offs

New England

The Alewife: A Successful Invader!

- Anadromous
- High fecundity (egg production),
- Spawns early in comparison with many other species.
- Occupies broad spatial niche in the lakes,
- Introduced as native predators declining,
- Schooling behavior,
- Highly efficient planktivore: behavior/morphology,
- Preys on larvae of competitors/predators.
- Thiaminase in tissues.
- An ecological focal point,
- Resiliency !!!
- An essential prey for stocked predators,
- Little commercial value.

New England

Alewife



VS.

Bloater



Lake Herring



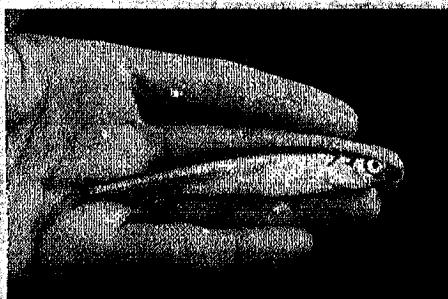
New England

Any Evidence of Competition between the Bloater and Alewife ??

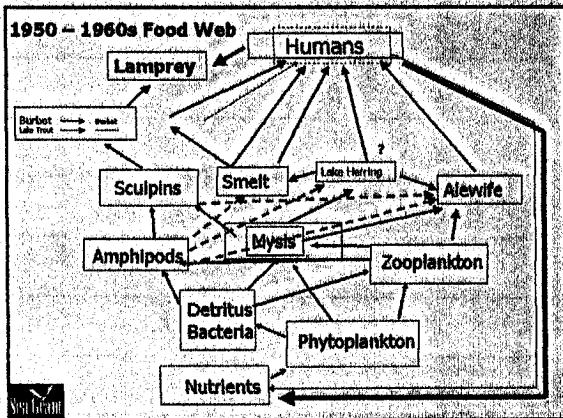
- Juvenile alewives and YOY bloaters overlap spatially and trophically
- Alewives are "superior" competitors due to their variable feeding behaviors and efficient feeding morphology
- Decreasing bloater abundance coincides with alewife proliferation
- Reduced year-class success of bloater
- Resource shifts by bloaters in presence of alewife
- Behavioral shifts timing of movement to hypolimnion by juvenile bloaters
- Character displacement of bloater feeding morphologies??

Sea Grant

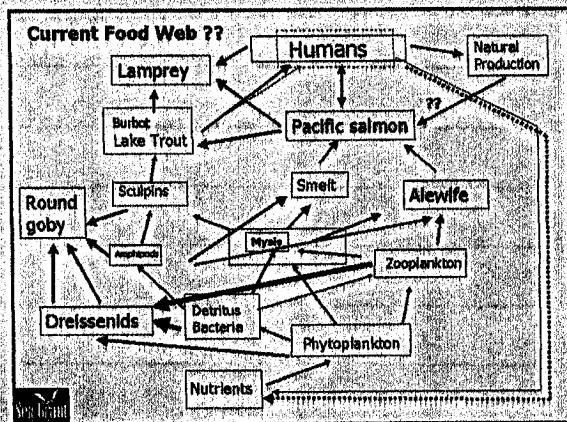
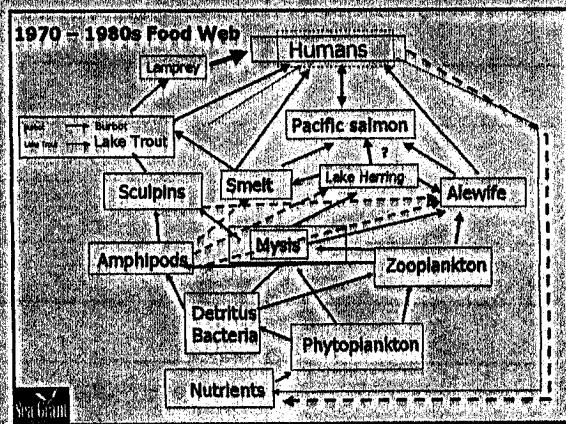
Rainbow Smelt



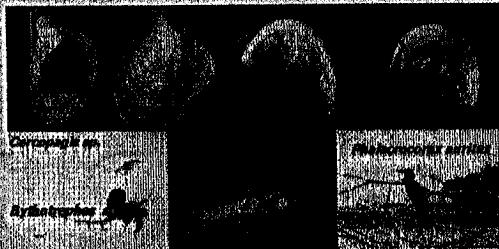
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Some Other "Nasty" Invading Species



Important Time Periods for Great Lakes Fisheries:

- Early-late 1800s: canal system, lamprey enter, watershed changes; deforestation, damming, siltation, unregulated salmon fishing; alewife introduced, salmon collapse and extirpated.
- 1870s and 1930s: lamprey predation, highly-prized fish populations collapse, increased harvest on alternative fish species, introduction of smelt and d.c. cormorant, smelt and alewife dominate offshore, alewife die-offs, human population growth, industry, nutrient inputs.
- 1950s and 1960s: population collapses of many native species, severe decline of lake trout/burbot, St. Lawrence Seaway, TFM, massive alewife die-offs, contaminant loading, hydroelectric power use, successful stocking, lamprey control, concern for nutrient loading, cormorants decline.
- 1970s and 1980s: beginning/expansion of stocking efforts, sportfishery ss, alewife and smelt under some control, successful ballast species introductions, nutrient/toxic abatement, signs of successful lake rehabilitation.
- 1990s and early 2000s: stocking rates/sportfisheries peak & decline, more ballast invasions with negative impacts on fish/ecosystems, cormorant populations explode, alewife/smelt decline, signs of successful lake trout reproduction..fisheries/ecosystem sustainability?
- And beyond: **INCREASING UNCERTAINTY !!**

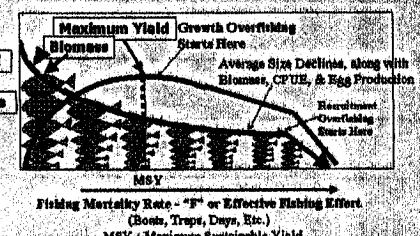
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Causes of Lake Ontario Fish Community Changes

- Destruction of fish spawning/nursery habitats
- Reduced access of fish to suitable habitats
- Unregulated/excessive fish harvests = **overfishing**
 - **Growth overfishing:** targeting fish that are too young results in decreased mean fish size and age with increasing fishing pressure; fish are harvested at a body size that will produce less than optimum number of recruits to replenish stock; more common in fisheries with long-lived and late maturing species.
 - **Recruitment overfishing:** targeting too many adult fish in prime spawning age-classes results in reduction of recruitment with increased fishing pressure; numbers of adult fish are harvested that will produce less than optimum number of recruits to replenish stock; more common in fisheries with short-lived, early maturing species.
- Species invasions and their negative impacts on the native fish communities
- Heavy nutrient loading and degraded water quality
- Direct and indirect effects of toxic contaminants
- *In essence:* a combination of reduced fish population size, reduced spawner biomass (and fecundity) and increased mortality of eggs and larvae.

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Growth & Recruitment Overfishing



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Results of Human Impacts on Great Lakes Fisheries Communities:

- A shift from dominant species that are large and long-lived (i.e. lake trout, Atlantic salmon, lake sturgeon) to smaller, short-lived fish species.
- A shift in populations with relatively stable populations (numbers and age) to unstable populations fluctuate considerably (numbers/ages).
- A shift from populations with diverse habitat preferences and diverse physical characteristics to populations that thrive only in narrow range of habitats.
- A shift in abundance of highly-prized, commercial fish species for human food to species to fish species that are of little or no commercial value.

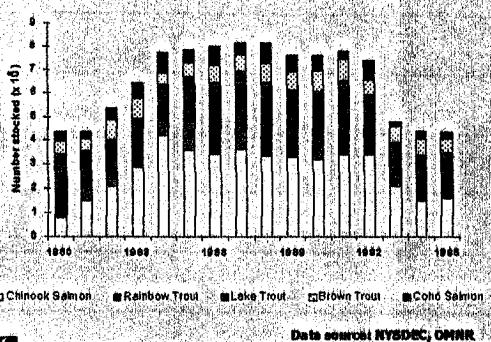


Ecosystem Management

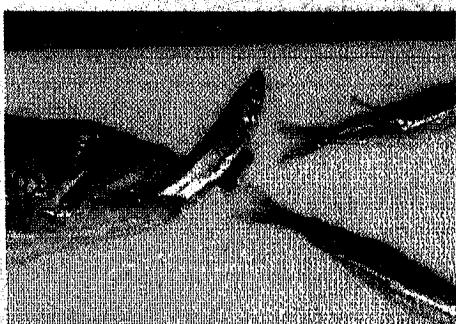
- Nutrient control
 - Use a *bottom-up* approach
 - Nutrient enrichment or nutrient abatement
- Biomanipulation
 - Use *top-down* approach to restructure aquatic food webs
 - Adding or removing fish at different levels in the food web
- Habitat enhancement or removal
- Water quality enhancement
- Water level regulation
- Reduction of toxic contaminant loading
- "People" management!!



Lakewide Salmonine Stocking in Lake Ontario



Data source: NYSDCC, OMNR



Great Lakes Management Policy Conflicts

- **Restoration of ecosystem health/native species**
 - Replace introduced/exotic species with native species that face increased food resource depletion, impaired reproductive abilities, unstable populations.
 - "Restoration" species need hatcheries to get their start.
 - Introduced salmon are becoming naturalized.
 - Cormorant management poses risk to fish restoration efforts.
- **Improvement of water "quality" for municipal and industrial users**
 - Additional water quality changes result in lower offshore system productivity and lower food quantity/quality to support fish;
 - and result in fish distribution/community changes from increased benthic production, light penetration.
- **Optimize recreational use of resources for stakeholders**
 - Economic revenues dependent on put-grow-and-take fisheries that need higher production of non-native forage species (very unstable populations), but global warming effects reduce habitats of many openwater species.
 - Conflicts with improved water quality, species restoration.
 - Natural production of introduced trout/salmon may effect stocking/hervests.



Goal Statement: Joint Strategic Plan for the Great Lakes (GLFC 1997)

- **To secure fish communities based on stable, self-sustaining stocks, supplemented by judicious stocking and provide an optimum contribution of fish, fishing opportunities and associated benefits to meet societal needs for:**
 - Wholesome food
 - Recreation
 - Cultural heritage
 - Employment and income, and
 - A healthy aquatic ecosystem

Source: GLFC (1999)

Lake Ontario Guiding Principles:

- Lake managed as whole ecosystem.
- Humans are part of the ecosystem, must strive to better understand ecosystem processes, public stewardship, public role in decision-making, lake managed to optimize human benefits.
- Protection and rehabilitation of fish communities and habitats are the most fundamental requirements for productive, sustainable fisheries.
- The lake has ecological limits to fish production.
- Self-sustaining and naturalized fish species provide diverse benefits.
- Stocked fish provide ecological and economic benefits; can support restoration/rehabilitation efforts.
- Protecting/rehabilitation of rare/endangered species is important for biodiversity.
- Protecting/rehabilitation of critical fish habitat in lake and tributaries are required for productive/sustainable fish communities and fisheries.
- Evaluation of management success is dependent on timely information from long-term assessment and research.

Source: GLFC (1999)

Lake Ontario Fish Community Objectives:

- **Nearshore:**
 - Maintenance of existing walleye, yellow perch populations; expansion into favorable habitats.
 - Population recovery of lake sturgeon; loss of endangered status.
 - Populations of basses attractive to anglers.
 - Increasing numbers of American eel, gizzard shad.
- **Offshore Pelagic:**
 - Diversity of trout/salmon, chinook as top predator; abundance of steelhead, fishable populations of brown trout and coho salmon.
 - Populations of Atlantic salmon at levels consistent for assessing restoration feasibility.
 - Amounts of naturally produced trout/salmon consistent with fishery/watershed plans.
 - Diverse prey-fish community, dominated by alewife.
- **Offshore benthic:**
 - Lake trout as top predator.
 - Population expansion of lake whitefish from northeastern basin to rest of lake.
 - Rehabilitated native prey-fishes: lake herring, bloater, deep-water sculpin.

Source: GLFC (1999)

Future Challenges to Managing the Lake Ontario Ecosystem and its Fisheries

- Invasive species and their impacts: What is the next invader?, Where is the system going? What will be the future fish communities?
- Other disruptive changes in the invertebrate community: *Diporeia, Mysid, Gammarus*? declines.
- Further alewife, smelt and slimy sculpin decreases?
- Research.... Research.... Research!!!
- Long-term data sets critically important, must be maintained.
- Need to get more political attention drawn to Great Lakes.
- Future socioeconomic sustainability: Increased public demand on fisheries resources vs. risk management.
- Current/future economic/political conditions restrict research and assessment programs.
- **UNCERTAINTY, UNCERTAINTY, UNCERTAINTY!!!**

See Grant